Chapter 1

INTRODUCTION

1.1 INTRODUCTION

This chapter discuss about the project background, the problem statement of the project, the objectives of the project and project scope.

1.2 PROJECT BACKGROUND

1.2.1 Aerodynamic characteristic of an airfoil.

The aerodynamic cross section of a body such as a wing that creates lift and drag on relative motion with the air is called an airfoil. Wing should be in proper shape for smooth lift. That is why airfoil size and shape playing an important role on airplane flight. Basic element of an airfoil is shown in Figure 1.1.

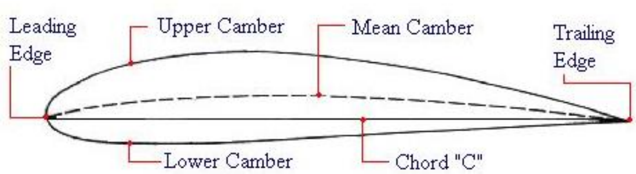
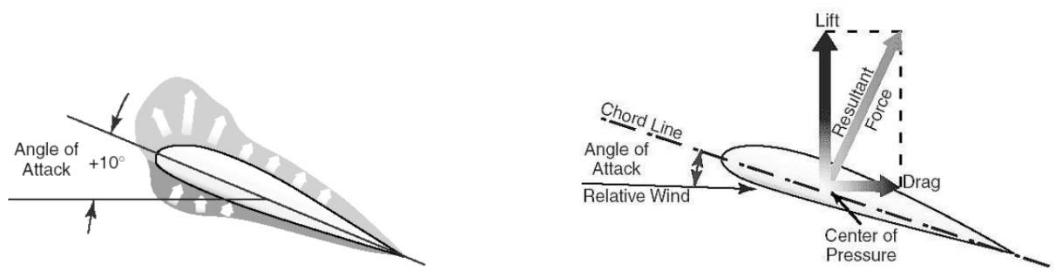


Figure 1.1: Basic elements of an airfoil

Source: http://www.aerospaceweb.org/question/airfoils/q0100.shtml

Lift is defined as force perpendicular to motion of the airfoil. The force parallel to the motion of the airfoil is called drag. As the air flow over an airfoil, the pressure over and under the airfoil changes due to the wind speed and circulation. To produce lift, a large part of the region over the wing has lower pressure than on the lower surface. Typical pressure distribution and resultant forces on an airfoil are shown in Figure 1.2 (a) and 1.2(b).



(a) Pressure distribution over an airfoil (b) Resultant forces on an airfoil

Figure 1.2: Airfoil characteristic.

Source: Jasvipul. S.C (2009)

For the purpose of analysis of air flow around an airfoil, the flow is divided into two regions: an outer region of inviscid flow, and a small flow region near the airfoil where viscous effects dominate. The region near the airfoil contains slow moving air and is known as boundary layer. The majority of drag experienced by a body in a fluid is created inside the boundary layer. The outer inviscid flow is faster moving air and determines the pressure distribution around the airfoil. The outer flow thus determines the lift force on the airfoil.

1.2.2 Flow in Low Reynolds number

The performance of airfoils operating at low relative wind speeds (low free stream velocities) has been of interest in modern subsonic aerodynamics. Typical applications where such airfoils can be used are wind turbines, remotely piloted vehicles, sail-planes, human powered vehicles, high altitude devices and many more. To characterize flows, the dimensionless Reynolds number (Re) is used. Reynolds number is defined as in Eq. (1.1) and gives a measure of the ratio of inertial forces to viscous forces and consequently quantifies the relative importance of these two types of forces for given flow conditions.

$$\mathrm{Re} = \frac{\rho V L}{\mu} \tag{1.1}$$

Where:

ρ = density of the fluid (kg/m³).

V = mean velocity of the object relative to the fluid (m/s).

L = characteristic linear dimension (m).

μ = kinematic viscosity (m²/s).

As Reynolds number is proportional to free stream velocity, the low wind speed flows (low free stream velocity) correspond to low Reynolds numbers. At low Reynolds numbers, the airfoils generate lesser lift, and encounter higher drags, bringing down the performance of the airfoil. This study gives a basic overview of low Reynolds number aerodynamic.

1.2.3 Computational Fluid Dynamics(CFD)

The effect of the Laminar Separation Bubble(LSB) and flow control method on low Reynolds number flow has been investigated by means of various experimental method, such as force measurement, velocity measurement, by using hot-wire anemometry and particle image velocimetry, pressure measurement with pressure transducer, flow visualization, with smoke wire, oil, Infrared thermography, etc. These systems are useful and accurate but also expensive and everyone cannot find the opportunity to use these methods. Therefore investigating all kind of aerodynamic phenomena via Computational Fluid Dynamic (CFD) is now popular and easy to use. By using CFD, the flow characteristic of a wing profile or any object can be easily analyzed. The biggest concern